BellBendCOLPEm Resource

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Sent: Wednesday, June 22, 2011 9:08 AM
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Subject: Bell Bend COLA - FINAL Request for Information No. 107 (RAI No. 107)- SEB1 5188 5189
Attachments: Final RAI Letter 107 - SEB1 5188 5189.doc

Attached is RAI No. 107 for the Bell Bend COL Application. Per our discussion on 6/21/2010, we understand that you have no further questions on this RAI. You are requested to respond by August 22, 2011. If additional time is required to respond, please inform me of your proposed schedule your earliest opportunity.

If you have any questions, please contact me.

Michael A. Canova
Project Manager - Bell Bend COL Application
Docket 52-039
EPR Project Branch
Division of New Reactor Licensing
Office of New Reactors
301-415-0737

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RAI Letter 107
Application Revision 2

6/22/2011

Bell Bend
PPL Bell Bend LLC.
Docket No. 52-039

QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

Request for Additional Information No. 5188

SRP Section: 03.07.02 - Seismic System Analysis
Application Section: 3.7.2

03.07.02-23

Follow Up to RAI 2660, Question 03.07.02-3 (Issued 7/27/2009, Response Received 10/21/2009)

AREVA is revising the original seismic analysis of the Nuclear Island (NI) common basemat structure which includes the use of a finite element model and the effects of the NI embedment. The applicant is requested to revise the table provided in its response to address how this change will be incorporated in the BBNPP site reconciliation of the U.S. EPR certified design for the NI common basemat structures.

03.07.02-24

Follow Up to RAI 2660, Question 03.07.02-9, Part 2 (Issued 7/27/2009, Response Received 8/26/2009)

a) In its response the applicant states that soil springs were not used in the boundary conditions as the pumphouse is assumed to rest on concrete backfill and/or on top of the Mahantango formation. However in its response to **Part (3)** of this Question, the applicant states that the response spectrum analysis used engineered backfill rather than concrete backfill. Therefore, the assumption stated in the response to **Part (2)** may be incorrect. The applicant is requested to clarify the boundary conditions used in the response spectrum analysis of the Essential Service Water Emergency. Makeup System (ESWEMS) and if it is intended to use engineered backfill under this structure, to provide the backfill properties and how these properties were determined. The applicant is also requested to provide the basis for determining the soil spring properties used in the response spectrum analysis and to provide an update to the FSAR to reflect the actual model used in the analysis.

b) In Figures 1-1 and Figure 1-2 provided with the response it is not clear what the boundary conditions are in the North-South direction of the dynamic models nor is it clear what the brown area is on the West side of the model in Figure 1-1 at the foundation level. The applicant is requested to provide this additional information and include it in the FSAR.

c) In Figure 1-2 at the base of the model, two pinned supports are shown which supposedly represent shear keys designed into the foundation. However in modeling these as pins, a restraint in the vertical direction is introduced at each location. The applicant should provide a justification for modeling the shear keys as pins and the physical basis for making this assumption. As part of the discussion the applicant should identify whether forces that prevent uplift occur at the pin locations and if so reconcile this result with the fact that the shear keys presumably are unable to prevent uplift.

03.07.02-25

Follow Up to RAI 2660, Question 03.07.02-9, Part 3 (Issued 7/27/2009, Response Received 8/26/2009)

a) In its response the applicant states that the FSAR will be revised to reference the correct figure (Figure 3.7-131) which is also being revised to include FIRS based on engineered backfill as well as concrete backfill. However the revised text to the FSAR does not provide the clarification that the analysis of the ESWEMS Pumphouse is based on engineered backfill and not on concrete backfill. The applicant is requested to make this clarification in the FSAR.

b) It is not clear as to which analysis method, time history or response spectrum, serves as the basis for the ESWEMS design as in FSAR Section 3.7.2.1.1 (Time History Analysis Method) it states that the seismic analysis develops the SSE structural response accelerations at discrete elevations for subsequent structural analysis and design, while in FSAR Section 3.7.2.1.2 a comparison is made between the time history results and response spectrum results and concludes the dynamic responses from response spectrum method envelope those from the SASSI analysis. The licensing basis for the design of this structure including modeling assumptions, methods of analysis, supporting subgrade and seismic input need to be clearly established in the FSAR. The applicant needs to revise the FSAR to provide this basis. In addition, the change identified under the COLA impact for FSAR Section 3.7.2.4, 3rd paragraph is incorrect. The correct section is FSAR Section 3.7.2.1.1.

03.07.02-26

Follow Up to RAI 2660, Question 03.07.02-10, Part 3 (Issued 7/27/2009, Response Received 8/26/2009)

In its response the applicant states that if peak seismic responses are used, calculation of fundamental system frequency of the steel platforms, hangers, and/or monorail is not required. In these cases the peak seismic acceleration is increased by a factor of 1.5 to account for multi-frequency input motion and multi-mode responses. In cases where the calculated frequency is beyond the cutoff frequency the zero-period acceleration (ZPA) is used in the analysis. The staff finds both of these approaches to be acceptable. However, the staff is requesting that the applicant: (1) identify what it is using as the ZPA; and (2) when the fundamental frequency is calculated to be less than that of the cutoff frequency to identify the method used and its technical justification to determine the seismic acceleration to be applied to these miscellaneous substructures.

03.07.02-27

Follow Up to RAI 2660, Question 03.07.02-11, Parts 3(a), (b) and (c) (Issued 7/27/2009, Response Received 8/26/2009)
In Question 03.07.02-11, the staff had asked the applicant to describe how modal responses were combined in the seismic analysis of the ESWEMS Pumphouse. The response provided by the applicant does not address how modal responses are combined but rather addresses how spatial components are combined. With reference to the guidance provided in RG 1.92, the applicant is requested to provide the methods used to combine the modal responses of the ESWEMS Pumphouse structure.

03.07.02-28

Follow Up to RAI 2660, Question 03.07.02-11, Part 5 (Issued 7/27/2009, Response Received 8/26/2009)
In its response the applicant states that the basis for the design loads is described in FSAR Section 3E which implies that the seismic design loads are obtained from the response spectrum analysis. The staff requests that the applicant clarify whether the response spectrum analysis is the basis for the loads, and identify what subgrade conditions have been assumed for the development of these loads. Specifically:

a) FSAR Section 3E-4 on page 3E-8 implies that the design loads are obtained from the response spectrum method. However, in FSAR Section 3.8.5.4.6, the applicant states that although the dynamic response spectrum analysis for the ESWEMS Pumphouse envelops the ICEC SASSI (V. 1.3) analysis results, the detail design of the base mat will be more refined and involve a three step analytical process including a time history analysis using SASSI.

b) In its assessment of the applicant's response to Question 03.07.02-9, part (3) the staff noted that the applicant has stated that the analysis of the ESWEMS Pumphouse is based on structural backfill. Please provide this assumption in the FSAR.

c) In FSAR Section 3.7.2.1.1, Time History Analysis Method, the applicant states that the seismic analysis develops the safe-shutdown earthquake (SSE) structural response accelerations at discrete elevations for subsequent structural analysis and design.

The licensing basis for the seismic loads and subsequent seismic design of the ESWEMS Pumphouse is not clear to the staff from the information provided by the applicant. The staff requests that the applicant clearly state in the FSAR the licensing basis for the seismic analysis and design of this structure.

03.07.02-29

Follow Up to RAI 2660, Question 03.07.02-11, Part 6 (Issued 7/27/2009, Response Received 8/26/2009)
The staff views that the applicant's response is acceptable for this structure. The ZPA's of the revised in-structure response spectra (ISRS) are now higher than those provided previously when the cutoff frequency was 50 Hz. If a cutoff frequency of less than 100 Hz was also used for the site reconciliation of the U.S. EPR Certified Design, the applicant is requested to identify the cutoff frequency used and address the impact of this cutoff frequency on the site reconciliation seismic results.

03.07.02-30

Follow Up to RAI 2660, Question 03.07.02-11, Part 7(a) (Issued 7/27/2009, Response Received 8/26/2009)

a) Normally response from the response spectrum analysis is compared with that from the SASSI analysis to determine if the structural response is similar. The applicant should describe any comparisons that were made in this regard and if none were done, explain why they were not.

b) It is not clear, on Figures 1-2 through 1-4, which curve is the roof and which is the mezzanine. The applicant should make the appropriate corrections to these Figures.

c) Explain the basis of note (2) in Table 2-1 that indicates that the difference in results between Table 1-1 and Table 2-1 is due to the fact that rollers were used in the response spectrum analysis and not in the SASSI analysis. Although rollers are used in the response spectrum analysis there are also two pin connections that tie the structure to the subgrade. Relative translations between finite elements supported by rollers should occur at relatively high frequencies and not be a significant factor in the differences between results in these two Tables.

d) Regarding note (3) in Table 2-1, since the response spectrum analysis used an engineered backfill and the structure is fairly rigid there should be a predominant vertical mode, just as there is in each of the horizontal directions, which reflects the dynamic response of the structure supported on vertical soil springs i.e, the engineered backfill. The applicant is requested to explain why a predominant vertical mode is not reflected in the results.

03.07.02-31

Follow Up to RAI 2660, Question 03.07.02-11, part 7(b) (Issued 7/27/2009, Response Received 8/26/2009)

In response to the staff’s question asking for a technical justification for not performing a refinement analysis of the 3-D finite element models used in the seismic analysis of the ESWEMS Pumphouse, the applicant has stated that no further refinement analysis is required and the results are conservative. However, no technical justification has been provided which supports this conclusion. The applicant is requested to perform such an analysis or otherwise provide technical justification for the results obtained from the models described. In addition, the applicant should provide a justification for using four node and three node elements in the model. As the walls and slabs are thick relative to the spans, an element that can also model shear distortion should be considered for the analysis.

03.07.02-32

Follow Up to RAI 2660, Question 03.07.02-12 (Issued 7/27/2009, Response Received 8/26/2009)

In its response the applicant states that in the SASSI model the approach by Newmark (1971) was used to consider the hydrodynamic pressure on the wall. Please clarify which wall the applicant is referring to in its response and explain how the Newmark method was applied in determining the water masses to be included in the seismic models used in the analysis of this structure. Specifically:

a) For both the wing walls and the pump well wall, the applicant is requested to describe the application of the Newmark method. The applicant should also identify if both an inertia mass and sloshing mass was used in the SASSI method as well as the response spectrum method of seismic analysis and to describe how these were determined. If a sloshing mass was not considered, the applicant should provide suitable technical justification for excluding it from the analyses.

b) The applicant has identified two nonlinear effects of the contained water parallel to the wing walls (potential cavitation and nonlinear distribution of hydrodynamic loads) along with references that are used as a basis for determining that these effects are insignificant, i.e. Chwang (1979) and Cheng (1996). To assist the staff in its evaluation of the applicant's response, the applicant is requested to provide copies of these references for the staff's review.

c) Due to the length and volume of contained water the wall is restraining, the applicant is requested to describe why the pump well wall should not be analyzed as a dam structure.

03.07.02-33

Follow Up to RAI 2660, Question 03.07.02-13, Part 2 (Issued 7/27/2009, Response Received 8/26/2009)

In response to part (1) of the question the applicant states that the capacity of the shear keys exceeded the demand forces provided in FSAR Section 3E, Table 3.4-5 of the FSAR. However, in the response to part (2) of the question, the applicant states that lateral friction forces along the base of the apron footprint area were relied upon to limit the forces in the shear keys. The staff is unable to determine the mechanism or mechanisms used to resist the lateral seismic forces and requests that the applicant describe how the resistance to lateral load is mobilized by the design and include the following information in its description:

a) Provide the lateral load design capacity of each shear key.
b) Compare the total lateral load design capacity of the shear keys with the total lateral earthquake demand forces determined from the structure's seismic response and identify from which seismic analysis method these were obtained (SASSI or response spectrum).
c) Provide the required horizontal resistance that needs to be provided through base mat friction and by numerical example demonstrate how this value is achieved.
d) Describe how the average values for dynamic condition including SSE loading on the shear keys listed in Table 3.4-5 were determined. Define what is meant by average values for these loads and what other dynamic loads if any were included.
e) Describe why the average depth of water was used in calculating the total dead load of the structure and why the minimum depth required for plant operation was not used. Provide the minimum depth of water and the difference this makes in the available friction force along the bottom of the foundation.
f) It is not clear to the staff from the information provided whether the seismic uplift force is insignificant. If the ESWEMS Pumphouse is rigid and the foundation stiff, the normal force used to determine the value of the lateral resisting friction force will be the dead weight of the structure (and any other vertical loads to be

considered) reduced by the effect of the ZPA of the vertical earthquake. If structural backfill is used, the fundamental frequency of the structure in the vertical direction is likely to be less than that which corresponds to that of the ZPA. This could result in an even larger reduction in the vertical load and further reduce the lateral resisting friction force. The applicant is requested to provide through numerical example why these effects were considered to be insignificant.

g) According to the response to Question 03.07.02-9 structural backfill is used under the ESWEMS. The coefficient of static friction between soil and concrete can vary from approximately 0.3 to 0.6. A coefficient of friction of 0.6 used in the analysis. Because the use of this value can lead to an over-prediction of available lateral resisting friction force, please justify the selection of this value.

h) Provide the technical backup which demonstrates that structural backfill can sustain the design loads imposed by the shear keys and provide the numerical result which demonstrates that a slip plane does not develop at the base of the shear keys within the structural backfill.

03.07.02-34

Follow Up to RAI 2660, Question 03.07.02-16 (Issued 7/27/2009, Response Received 2/3/2010)

In the background portion of its response the applicant states that certain structures, systems and components (SSCs) within the fire protection/suppression systems (including the Fire Water Storage Tanks and Fire Protection Building) comply with SRP 3.7.2 Acceptance Criteria 8A because they do not fall into the category of SSCs that have the potential to interact with their proximate Seismic Category I SSCs. Criterion 8A states that “The collapse of the non-Category I structure will not cause the non-Category I structure to strike a Category I structure.” However, according to the applicant, both the Fire Water Storage Tanks and Fire Protection Building are designated as Seismic Category II-SSE (SC II-SSE) and are designed to remain elastic under SSE excitation. Therefore they are designed not to collapse and as such meet Acceptance Criterion 8C of SRP 3.7.2 instead of Acceptance Criterion 8A. The applicant is requested to clarify its response in this regard.

In **Part 1** of its response the applicant states that “Both Seismic Category II and Seismic Category II-SSE SSCs will be designed to remain elastic at the SSE excitation.” The staff finds this to be acceptable. It also states that the design will be based on codes and standards such as ASCE 4-98, ACI 349 as appropriate. In Question **03.07.02-16, Part 1(a),** the staff asked for the seismic inputs, seismic models, and loading combinations. This information has not been provided. The staff again requests that the applicant provide the seismic inputs, seismic models, and loading combinations that demonstrate SC II-SSE structures remain elastic under an SSE excitation. In addition, Table 3.2-1, under the column “Comments/Commercial Code,” lists the International Building Code (IBC) as applicable to SC II-SSE Fire Water Storage Tanks and Fire Protection Building. The IBC philosophy for seismic design is to determine a ductility factor R used to reduce the base shear due to seismic load. As a result the structure’s design will result in inelastic behavior under an earthquake, not elastic behavior. The staff requests that the applicant explain why the IBC code is listed for these SC II-SSE structures which are to remain elastic under SSE excitation and in addition to identify the seismic inputs, seismic models and methods of analysis to be used to determine the earthquake design loads applicable to these structures.

In the third paragraph of the response to Question **03.07.02-16, Part 1,** there is a philosophical discussion of seismic margin as it pertains to reactor core damage. The applicant is requested to clarify why this discussion has been introduced into the response and explain its relevance to the design of the SC II and SC II-SSE portions of the Fire Protection System.

In **Part 2** of Question **03.07.02-16**, the staff had asked the applicant to describe the basis of the design response spectra used to analyze SC II and SC II-SSE fire protection SSCs. In its response the applicant has stated that SC II and SC II-SSE will be designed using site specific spectra unless bounded by the U.S. EPR CSDRS. However the applicant did not identify the site specific spectra or describe how this spectra is determined. The applicant is requested to provide this information and include it in the FSAR.

In its response to Question **03.07.02-16, Part 3,** which provides the methods of analysis and acceptance criteria for the Fire Protection System that are SC II-SSE and SC II, the applicant states that for above-ground portions these are provided in U.S. EPR FSAR Section 3.9.2.2.2, which references the AREVA Piping Topical Report, and in U.S. EPR FSAR Section 3.12. For buried segments the applicant states these requirements are provided in U.S EPR FSAR Section 3.12.3.8, which references the AREVA Piping Topical Report. The AREVA topical report presents the U.S. EPR Design Certification code requirements, acceptance criteria, analysis methods and modeling techniques for ASME Class 1, 2 and 3 piping and pipe supports while Section 3.12 addresses ASME Code Class 1, 2, and 3 piping systems, piping components, and their associated supports. However, in Table 3.2-1 for Fire Suppression Systems for ESWEMS Pumphouse and Fire Protection Building and for Standpipes and Hose Stations for the ESWEMS Pumphouse, under the “Comments/Commercial Code” column, the code listed is the ANSI/ASME B31.1 piping code. Therefore, it appears that the FSAR sections provided as references by the applicant are not applicable to SC II-SSE or SC II fire protection piping. The staff requests that the applicant provide additional information which specifically describes the methods of analysis (seismic models, seismic input, etc.), and the piping design codes that will be used for SC II and SC II-SSE Fire Protection Systems and include this information in the FSAR. In addition the applicant should identify how the functionality of the SC II SSE Fire Protection Piping will be assured through the use of the proposed methods and applied piping code.

03.07.02-35

Follow Up to RAI 2660, Question 03.07.02-18, Parts 1-3 (Issued 7/27/2009, Response Received 2/3/2010)

The applicant in its response states that it will use the same methodology as that described in AREVA’s response to U.S. EPR **RAI 248, Question 03.07.02-56**. In the methodology described, buildings are designed in such a way that the deformation, collapse, or partial collapse due to SSE loads is controlled by introducing an eccentrically braced frame in steel structures and a “crumple zone” in concrete structures. AREVA stated that this meets Acceptance Criteria 8A of SRP 3.7.2. The staff did not accept AREVA’s response and requested additional information. In its response to the staff’s request for additional information, AREVA stated that the Access Building

(AB) and Turbine Building (TB) would be designed to the same codes and standards and have a factor-of-safety that is equivalent to that of a Seismic Category I structure. This information is presented in the U.S. EPR FSAR within double brackets meaning it is conceptual design information. The staff is requesting that the applicant either:

a) Concur that the design basis for these structures will be to the same codes and standards and have a factor-of-safety that is equivalent to that of a Seismic Category I structure, or;

b) Propose an alternative design method such that a failure of these structures (AB) (TB) will not impact the safety function of a Seismic Category I structure. In its description the applicant should provide the following addtiional information:

1. Describe the design process that will be applied to these structures and describe in detail how they will be analyzed for SSE load conditions.
2. For each building describe the building design including, if used, the application of eccentrically braced frames and the use of crumple zones and describe how the design of each structure will prevent seismic interaction with a Category I structure.
3. Describe the collapse sequence and how the collapse will be controlled under an SSE event such that failure occurs in a direction away from a Category I structure.
4. Provide figures that depict the eccentrically braced frame and/or crumple zone as they apply to each of the structures.
5. Describe how the displacement of the TB and AB will be determined to verify that the separation distance to Category I structures are adequate during an SSE event.

Also the applicant is requested to add the Access Building (AB) to Table 3.7-8 and revise Table 3.2-1 to reflect the fact that the AB is now classified by AREVA as a Seismic Category II structure.

03.07.02-36

Follow Up to RAI 2660, Question 03.07.02-18, Part 4 (Issued 7/27/2009, Response Received 8/26/2009)

FSAR Section 3.7.2.8 on page 3-46 lists a conventional seismic ESWEMS pumphouse as a structure that has the potential to interact with Seismic Category I SSCs. If this structure does not exist or if it is incorrectly referring to the Seismic Category I ESWEMS pumphouse it should be removed from the list of structures on page 3-46. If it does exist, i.e. in addition to the Seismic Category I ESWEMS pumphouse there is also a conventional seismic ESWEMS pumphouse, the applicant is requested to address the potential impact of its seismic response on Seismic Category I SSCs.

03.07.02-37

Follow Up to RAI 2660, Question 03.07.02-20 (Issued 7/27/2009, Response Received 8/26/2009)

Acceptance Criteria 11 of SRP 3.7.2 states that to account for accidental torsion an additional eccentricity of +/- 5 percent of the maximum building dimension shall be assumed for both horizontal directions. This torsion is in addition to the torsion calculated from the dynamic analysis of the building seismic model or that calculated using static factors. It appears from the applicant's response that this additional eccentricity was not considered in the design of the ESWEMS. The applicant is requested to demonstrate through numerical examples that the design capacity of the structure is sufficiently conservative that even with the addition of a 5 percent eccentricity as defined in Acceptance Criteria 11 of SRP 3.7.2 the structure would remain within its code allowable design values.

Request for Additional Information No. 5189 Revision 2

SRP Section: 03.07.03 - Seismic Subsystem Analysis
Application Section: 3.7.3

03.07.03-2
Follow Up to RAI 2661, Question 03.07.03-1, Part 1 (Issued 7/27/2009, Response Received 8/26/2009)
In Table 1-1, the term "equivalent outcropping motion at foundation level" is used. The staff requests that the applicant provide a description of this term and explain whether it, in fact, satisfies the definition in RG 1.208 of outcropping motions assuming no soil/rock in the column above the depth at which the spectra are computed. In the same table, the term "surface structure with outcropping ground motion at foundation level" is specified. The applicant should indicate whether the foundation level is coincident with the ground surface and whether the outcropping motion is defined as a surface motion.

03.07.03-3
Follow Up to RAI 2661, Question 03.07.03-1, Parts 10 and 11 (Issued 7/27/2009, Response Received 10/21/2009)
With respect to Part 10, the process used by Bell Bend does not appear to account for the potentially large uncertainty in computed displacements associated with the seismic hazard at the site. The applicant is requested to address the uncertainty in the maximum displacements generated from the time history integration by comparing these to the displacements associated with the Probabilistic Seismic Hazard Analysis (PSHA) at the design return period as well as at the performance goal for the site.
With respect to Part 11, the reference provided by the applicant does not address how building anchor movements are determined for use in the qualification of buried piping. The applicant should describe how this is done directly in its response or provide the correct reference. The applicant should also include this information in the FSAR.